Public Response to a Catastrophic Southern California Earthquake: A Sociological Perspective

James D. Goltz,[a] **M.EERI, and Dennis S. Mileti,**[b] **M.EERI**

This paper describes a hypothetical scenario of public response to a large regional earthquake on the southern section of the San Andreas Fault. Conclusive social and behavioral science research over decades has established that the behavior of individuals in disaster is, on the whole, controlled, rational, and adaptive, despite popular misperceptions that people who experience a disaster are dependent upon and problematic for organized response agencies. We applied this knowledge to portray the response of people impacted by the earthquake focusing on actions they will take during and immediately following the cessation of the shaking including: immediate response, search and rescue, gaining situational awareness through information seeking, making decisions about evacuation and interacting with organized responders. Our most general conclusion is that the actions of ordinary people in this earthquake scenario comprised the bulk of the initial response effort, particularly in those areas isolated for lengthy periods of time following the earthquake. [DOI: 10.1193/1.3575728]

INTRODUCTION: THE SCENARIO

The scenario disaster addressed in this paper is a major earthquake on the southern San Andreas Fault, a magnitude 7.8 event that ruptures a 300 km length of the fault and impacts an eight-county region in Southern California (see ShakeMap in Porter et al. 2011, this volume). This earthquake scenario, the most detailed and carefully constructed to date, estimates that the earthquake would cause 1,800 deaths, 50,000 injuries that require hospitalization, displace 255,000 households, and cause $213 billion dollars in direct and indirect damage (Jones et al. 2008). The disaster hypothesized in this scenario would be the worst natural disaster in American history, striking an urban region populated by more than 20 million people with a building inventory valued at $2 trillion. The hypothesized earthquake occurs at 10:00 a.m. on a weekday and assumes that working people are on the job, school-age children are in the classroom, many are traveling on streets and highways, and businesses are open with customers present. Upon the occurrence of the scenario earthquake lasting approximately 2 minutes and causing violent ground motion, buildings will be severely damaged, utilities disrupted, lifelines severed, and the normal routines of millions of people will be altered for weeks, months, and years. For additional details of the scenario, see Porter et al. (2011, this volume). Scenarios fill an important role in shaping public

[a] California Emergency Management Agency, 1200 East California Blvd., Mail Code 104-44, Pasadena, CA 91125
[b] University of Colorado, Boulder (Professor Emeritus), 1 Ridgeline Way, Rancho Mirage, CA 92270

Earthquake Spectra, Volume 27, No. 2, pages 487–504, May 2011;

policy by detailing the likely consequences of major disruptive events and setting the stage for measures that improve resiliency through mitigation and preparedness.

SOCIAL TRANSFORMATION IN DISASTER

In a real sense, this is one earthquake that creates multiple disasters, requires an unprecedented level of response, and affects both national and world economies. The impacts will include severe damage to buildings and infrastructure, disruption of lifelines and utilities, major secondary hazards, particularly fires, disrupted communications and resulting isolation of some communities for days before organized response will be available. The organized agencies of response—fire departments, law enforcement agencies, medical emergency responders, utility and lifeline operators, and agencies at the local, regional, state, and national levels that coordinate response—will experience difficulties and delays in mobilizing resources and gaining access to areas in need of immediate emergency response. These delays in response are not due to negligence or lack of competence on the part of organized response agencies but to the large-scale impacts of this scenario earthquake on Southern California communities.

In California, when an emergency or disaster exceeds the capacity of a single jurisdiction to effectively respond, mutual aid agreements draw specific types of assistance from non- or minimally affected jurisdictions. These mutual aid pacts include fire, law, and emergency management functions, are codified into law, and are exercised frequently for many types of emergencies. The catastrophic earthquake scenario hypothesized in this paper would require mutual aid on an unprecedented scale, from the entire state, adjacent states, and, for some functions like fire, from the nation as a whole. Organized response on this scale will require time to mobilize and will face significant obstacles to deployment, including regional disruption of transportation and communications, damage to airports and harbor facilities, uncontrolled fires, and significant impacts on local emergency management agencies that must initiate response as well as assess the situation and clearly identify mutual aid needs.

In the face of the immediate and urgent needs for search and rescue, fire suppression, debris clearance, medical assistance, and safe shelter, survivors of the earthquake will take immediate action to address these needs. This response by local residents is immediate, spontaneous, loosely organized, and represents what social scientists have described as a transformation of social relations from routine to urgent, from normal self-interested actions to an emphasis on community survival, and from recipients of emergency assistance to providers of assistance. What some see as post-disaster chaos is a new set of disaster-specific norms that guide human behavior in a crisis (Mileti 1999, Turner 1986, Barton 1969). The actions for which these norms provide guidance are to save lives that are imperiled, to reduce suffering, to address immediate threats such as fires and gas leaks, to provide emotional support, to assess and define the situation, and to plan for the immediate future. This translates to self-protection, assuring the safety and protection of others in the immediate environment, including rescuing those who are trapped in debris, reuniting with family, assisting neighbors, gaining an understanding of the situation through information seeking, and addressing the issue of whether one may remain in place or move to another, presumably safer location.

Individuals, families, and neighbors will work in small groups, largely unsupervised, to respond to the disaster and will use whatever tools are available to them, including the acquisition of resources (sometimes mistakenly labeled as looting) from local businesses to achieve their goals. They will continue these efforts for hours and days until organized response personnel appear and in many instances will continue to work alongside organized responders until fatigue or the need for equipment and expertise, available only to the trained, takes precedent over their efforts. In general, the emergent public response trails off as organized responders are available and as relatively easy rescues, the provision of first aid, the suppression of small fires and other needs give way to more complicated rescues, aid for serious injuries and major fire suppression, beyond the capability of mostly untrained responders becomes salient (see Figure 1). We do not mean to imply that organized response is absent immediately following the earthquake (Kreps 1991); initial organized response will require time to ramp up and in the interim, localized spontaneous response will address the pressing need for assistance. In addition, emergent activity after the earthquake does not cease as those on the fringe of the impact area begin the recovery process even as organized emergency response supersedes spontaneous emergency actions in the high impact zones.

In this paper, we will apply this model of human behavior in disaster to the scenario of a major earthquake in Southern California, a model validated in thousands of studies of disasters of all types worldwide (see summaries in Tierney et al. 2001, Mileti 1999, Drabek 1986). It will challenge many prevailing stereotypes of post-disaster behavior, including panic and irrational flight during the disaster, dazed and incapacitated dependency after the event, a lapse into criminal behavior by many, taking advantage of the absence of control agencies to loot stores or homes, and in general, being a burden to already overtaxed response agencies struggling to mobilize and address the major impacts of the disaster. In fact, those who are typically the targets of control in the Social Breakdown Model, poor and minority people, are actually more likely to be victims, to experience significant losses, and to require longer recovery time than economically advantaged people of the ethnic majority.

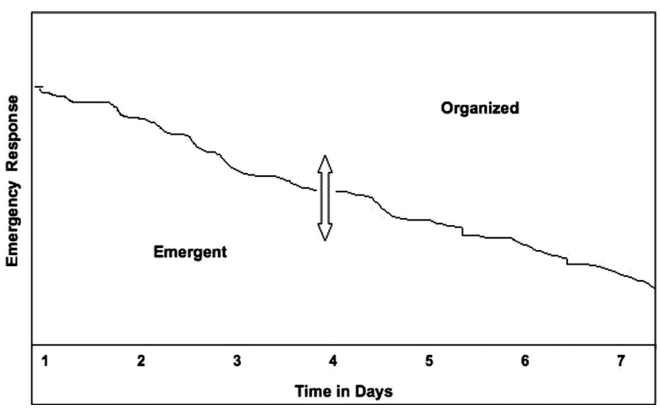

Figure 1. Emergent and organized response over time.

Thus, the purpose of this paper is to provide an evidence-based portrait of human behavior in disaster that challenges the Social Breakdown Model and provides decision makers a valid basis for planning and public policy. There is little in this paper that directly contributes to the social science literature on human behavior in disaster, as social scientists who study disaster will have heard these conclusions in the past, but many readers from other disciplines represented in this volume may be unfamiliar with these insights, and it is to them that this paper is addressed.

SCENARIO GENERATION METHOD

We sought to use a method that would enable us to generate realistic estimates of public response to the scenario earthquake. The method selected superimposed realistic and documented accounts of public behavior in past analogous disasters on the impacts imposed by this earthquake. We implemented the method as follows.

First, we took as our input the output of other scenario groups who estimated the earthquake's impacts, including the number of fire ignitions, damage to buildings and life lines, disruption and damage to the transportation infrastructure, and much more. We then made assumptions about what these impacts would mean to the ability of organized emergency response organizations to respond to the volume of demand for their services, and, perhaps just as important, for mutual aid response to converge to all the locations in Southern California that would be in need of service delivery.

Second, we drew on the extensive empirical record, begun over a half-century ago, and based on disasters from around the world regarding the behavior of members of the public, both victims and nonvictims. Moreover, several authors have synthesized that research record including Barton (1969), Mileti et al. (1975, 1999), Drabek (1986), and, most recently, Tierney et al. (2001). Still others have generalized from these findings and syntheses to create general "empirically validated theory" about human behavior in disasters (Turner 1986). We extracted repetitive descriptive accounts of public behavior in historical disasters that comprised this record to hypothesize behaviors in this scenario.

Last, we superimposed the patterns of public response grounded in historically investigated disasters on the scenario damage estimates provided by others to inform the estimates we made about public response to the scenario earthquake herein reported. This method was, obviously, inherently qualitative; however, it rested on a strong and elaborate record of actual empirical findings about how real people have behaved in real and analogous disasters. All of the behavioral estimates we provide below for this scenario are evidence-based, that is, we only provide descriptions of public response that have been repetitively documented in multiple disaster events of like magnitude to the scenario earthquake.

PUBLIC RESPONSE

In the sections that follow, we have selected several post-earthquake actions taken by people in the impacted area of the M7.8 earthquake scenario. They are the immediate response to the earthquake shaking, activities involving the rescue of people trapped or incapacitated by the earthquake, information seeking to define the situation, making decisions regarding shelter, and taking on other response roles typically performed by the

organized responders but that, in the initial phase of the disaster, are performed by members of the public.

INITIAL BEHAVIORAL RESPONSE

By initial behavioral response, we mean the actions taken at the onset of the earthquake, when a person first perceives movement and continuing until the shaking has ceased. These actions, as characterized over the years have generally fallen into two models of behavior, the Social Breakdown Model and the Rational-Adaptive Model. The Social Breakdown Model suggests that the disaster social situation is chaotic, that people faced with sudden violent shaking will panic, act irrationally by running regardless of the danger that movement may present and ignoring both prior training and situational cues that suggest that other actions may prevent injury or death. The immediate aftermath of the disaster, according to the Social Breakdown Model, is a situation requiring immediate intervention and care for fearful, traumatized victims and a strong show of control to prevent antisocial behavior among those who may take advantage of disaster-induced lapses in the exercise of authority.

One of the clearest statements of the Breakdown Model of panic in disaster is found in a description of "human reactions" to earthquake shaking by seismologist Charles Richter (1958):

> Fright and panic are such regular effects of strong shaking that they form an established part of all intensity scales. Persons and populations differ according to their previous experience, but only an abnormally cold-blooded person can remain calm when the structures over his head are being damaged and the ground under his feet is shaking so as to destroy the basic feelings of security. The most universal impulse is to run, even when already outdoors.

This "common" reaction in situations of potential danger, however, is challenged by empirical studies of fires, floods, earthquakes and other natural and technological disasters. According to the Rational-Adaptive Model, rather than panic, people who experience a sudden crisis respond actively and consistently as possible with pre-disaster roles. It is this model that is supported by decades of social science research on many types of disasters in different parts of the world. The model has received empirical support in fires where the response of people was to use familiar exits, assist others and, where possible, to fight the fire (NIST 2005, Aguirre et al. 1998, Paulsen 1981). Studies of initial behavioral response in California earthquakes were conducted based on surveys with consistent questions following three earthquakes, Whittier Narrows (M5.9 on 1 October 1987), Loma Prieta (M6.9 on 17 October 1989) and Northridge (M6.7 on 17 January 1994). Goltz (with Russell and Bourque, 1992; 2006) found that the self-reported behavior of persons who experienced these earthquakes was, on the whole, controlled, rational, and adaptive and varied with where they were located at the time of the earthquake, levels of fear, the presence and identity of others, age, and gender.

In these surveys, respondents were asked: When you felt the earthquake, what was the very first thing you did? Based on responses to this question and analysis in the context of various situational and demographic variables, Goltz discovered that the modal response of

persons at home or at work was to avoid hazards, take cover in a doorway (still a recommended action at the time of these earthquakes) or under sturdy furniture and, if driving, to pull to the side of the road. In no locational context including an unfamiliar place was running or running outside a dominant behavioral response in the three earthquakes.

Many persons expressed high levels of fear. The Social Breakdown Model suggests that fear would be associated with ill-considered flight and some of the disaster research literature implies that self-protective action might be taken despite considerable fear. On the contrary, Goltz discovered that as expressed fear increased, so did the propensity to take cover in the earthquake. The presence and identity of others proved to be an important influence on immediate response in the earthquakes; those who were in the presence of dependent children when the earthquake occurred were more frightened than those who were alone or with other adults. The presence of dependent children was a significant factor in taking cover and dependent children were typically the objective in the behavior "went to others," a behavior characteristic of young married female respondents who were frightened by the earthquake and clearly acting in a consistent manner with predisaster parental roles. Remaining in place, which was the behavioral choice of a majority of Loma Prieta and Northridge respondents, particularly older persons, was quite rare (less than 5%) among those who were in the presence of dependent children (Goltz 2006).

Some variant of the Modified Mercalli Intensity (MMI) Scale has been employed for decades, matching graduated earthquake shaking levels to damage, ground deformation, and human behavior. The human behavior component portrays increasing levels of perception of movement and alarm as the intensity of ground shaking increases, and at intensity VII, declares that "everybody runs outside." This scale, which was assembled by seismologists and engineers early in the last century with little, if any, input from social scientists can be an easy target, but its persistence and probable contribution to stubborn stereotypes of human behavior in disaster as irrational merits comment in this analysis.

In Goltz's study of behavioral response in three earthquakes (Whittier Narrows with MMI up to VIII; Loma Prieta with more widespread MMI VIII and some IX; and Northridge also up to MMI IX), the level of shaking intensity was not consistently associated with any immediate response behavior. The shaking intensity experienced failed to predict running outside in any of the three earthquakes. Shaking intensity was a very minor influence on the other behaviors examined, and not a consistent one across the earthquakes studied. In Northridge, shaking intensity was related to taking cover at home among those who were in areas exposed to lesser levels of shaking. Although the author hypothesized that lower intensities might be associated with remaining in place during the earthquakes, intensity did not predict remaining in place in models constructed for any of the three earthquakes. Nor was shaking intensity experienced associated with going to others or with driving behavior.

If we can generalize the findings above, which are clearly consistent with the Rational-Adaptive Model of human behavioral response in an earthquake, we can make some general statements based on empirical evidence about a large earthquake on the San Andreas Fault in Southern California. Although the M7.8 scenario earthquake is significantly larger than those studied by Goltz and others (with very extensive MMI VIII and IX), the weak relationship between intensity and response suggests that behavior during the shaking will be

similar to that reported in earthquakes of lesser magnitude. Thus, we would argue that taking cover and remaining in place will be the most prevalent actions and that running will be far less prevalent than suggested by the Social Breakdown Model. The propensity to take cover is, of course, a learned response and one emphasized in earthquake public education campaigns such as California's annual ShakeOut drill, which encourages those who experience an earthquake to "Drop, Cover, and Hold On." There is evidence for the efficacy of such campaigns, though the message must be consistent, repeated, and multichanneled to ensure consistent compliance. The relatively low death toll for an earthquake of M7.8 can and has been attributed to California's stringent building code and programs of hazard mitigation, but one must also credit effective public education regarding appropriate and location-specific self-protective actions in an earthquake.

SEARCH AND RESCUE BY SURVIVORS

Search and rescue refers to efforts by organized and spontaneously assembled emergent groups to locate and extricate persons trapped in debris, administer medical aid if necessary, and coordinate the transportation of seriously injured persons to hospitals. In the context of our two models of human behavioral response to disaster, particularly a major disaster like a M7.8 earthquake in urban Southern California, we would look for either a population traumatized into dazed incapacity dependent upon organized response agencies (Social Breakdown Model) or a population operating under an "emergent norm" calling for focused efforts to assist those in need—first family members, then neighbors closely by, followed by anyone requiring assistance (Rational Adaptive Model). In the immediate aftermath of an earthquake disaster, a first priority would be to assist people injured during the shaking.

Decades of research have demonstrated that in the early stages of a disaster, perhaps during the first 3–6 hours after the earthquake, nearly all search and rescue efforts are performed by family members, neighbors, and community residents in the immediate vicinity of buildings that have collapsed or partially collapsed. Most of the "live" rescues will be accomplished in the first few hours by these spontaneous search and rescue groups who work with limited resources and skills but have the advantage of physical proximity to collapsed structures. For example, Hyogo (Japan) Prefectural officials estimated that there were 20,000 live rescues following the Kobe earthquake of 17 January 1995, only 5,000 of which could be attributed to organized rescue teams and the remainder—75% of the total—were rescued by other survivors (Goltz 1996). Organized search and rescue teams require time to mobilize and will be hampered by severe damage to transportation and communications lifelines, as well as secondary effects of the earthquake including fire following and potential dam collapse.

Upon the cessation of shaking, people in the Southern California region who have experienced severe shaking will survey their surroundings; if at work, they will check on the well-being of their coworkers, if at home, the members of their household, and if in a public place, others who happen to be in the vicinity. This basic "emergent" norm, calling for assistance to those who have become victims of the earthquake, is highly salient during the immediate aftermath of the earthquake and provides the motivation for those who have survived the earthquake with minimal or no injury to devote themselves to those who are in need of assistance (Drury et al. 2009). This assistance is first expressed as a desire to help

those who are trapped in debris and possibly injured. Most of these early rescues carried out by spontaneously assembled groups will be relatively uncomplicated, requiring few if any tools with first aid administered by those who happen to be present. If transportation is available and routes to local hospitals are unencumbered, the injured will be transported to nearby hospitals.

During the first six hours or so, search and rescue by survivors of the earthquake will be particularly intense in the areas that have experienced the most significant ground motion including eastern Los Angeles County and the cities of San Bernardino, Riverside, Palm Springs, Lancaster, and Palmdale. Initially, search and rescue will focus on collapsed or partially collapsed multifamily residential buildings and businesses in the older sections of these cities, but given the relatively unsystematic approach of spontaneously organized search and rescue groups, activity will be focused on the immediate area in which groups form rather than according to any plan. For these groups operating in the first six hours, the full extent of the area damaged is unknown, and with limited access to information about broader impacts, activity is highly localized.

Once locally organized search and rescue teams arrive at the scenes of collapsed structures, they are likely to encounter ongoing search and rescue efforts by spontaneously formed groups who provide informal briefings to the organized teams and continue to work in cooperation with the organized responders, assume subordinate roles in the effort or redeploy to other collapse scenes where organized teams are not present. In most cases, spontaneous teams will have rescued many people trapped in the debris of badly damaged or collapsed buildings before organized teams appear on the scene due to the length of time necessary for official teams to mobilize. These rescues will be the less problematic ones that require minimal skills and simple tools. The remaining rescues which fall to the organized teams will be more difficult, requiring both training and more specialized rescue equipment. These rescues are also likely to involve more serious injuries, thus requiring greater on-site medical expertise and close coordination with emergency vehicles available to transport the injured to hospitals.

SEEKING INFORMATION

Disaster research has shown that once those who have experienced a sudden onset disaster have ensured their own survival and assisted others in their immediate vicinity, they typically seek information. In ambiguous situations, the information sought may involve a credible definition of what just happened and whether the danger has passed. They certainly want to know the status of family and friends who may have been affected by the event and report their own status to those outside the area of impact. In situations in which the disaster agent is readily identifiable, information sought may include an understanding of how extensive the impact was, how officials are responding and how to secure assistance. In short, people seek to define the situation.

The immediate sources of information include others who have experienced the event and the news media of radio, television and newspapers. Social scientists have discovered that a two-step process is involved in which information is received, mainly from the media and a second, in which information is discussed and personalized among family, friends

and significant others. The disaster research literature on information seeking addresses the outputs and internal functioning of news media organizations as well the importance of informal sources including friends, family members and others present to confirm information received, agree on appropriate courses of action and the roles that must be played in responding to the information received (Turner and Killian 1987). Despite advanced technology that has magnified the importance of the mass media, "the average person still places great reliance on an informal network of people whose judgment and opinions are respected" (op cit, p. 38). Turner et al. (1986) found that while 88% of respondents in a survey conducted following a local earthquake cited various forms of media as the chief source of information about the earthquake, over two thirds reported that their source of interpretation of earthquake information was obtained from friends and coworkers.

In the M7.8 scenario earthquake, we can confidently predict, based on the disaster research literature, that information seeking will commence immediately after the shaking stops. The response of persons in close proximity to one another after the shaking has ceased is to seek information on the wellbeing of others and to assist them, if necessary. Those who are at work, school, in a public place or preoccupied with assisting others are unlikely to have immediate access to the media of radio or television while those who are at home or driving will have more immediate access. In some cases, electric power will be lost or televisions damaged and television access will be unavailable. In these situations, which will be particularly salient in the eastern region near the fault, persons will shift to battery-powered radios for information and news about the earthquake. Whether through television or radio, early information will be minimal, as radio and television studios will face their own challenges involving toppled equipment and damage to broadcast infrastructure.

Concurrent with information seeking through the media, persons who have experienced the earthquake will be engaged in intense discussion of the event, its extent, its impact on themselves and the immediate environment, and how organized response agencies are or ought to be assisting them. They will also seek information on the status of family and friends potentially impacted by the earthquake and seek to reunite with them. Most attempts to do so will involve telephone contact or computerized media (smart phones or text messaging), which, like radio and television infrastructure, is likely to be disrupted by this major earthquake. The inability of many to reach family and friends or unite with them will lead to anxiety, but this anxiety does not lead to incapacity or resignation. Most will persist until information is received. Within the first three to five hours, as media sources come back online and word of mouth spreads, people begin to realize the scope of the disaster, that it was not an isolated event that impacted them but a region-wide disaster and that the "Big One" had in fact occurred.

As a consequence of this emerging realization, people begin to shift their identification away from themselves as individuals and begin to identify with the entire affected community of victims. Although it is likely to take a little longer to reach everyone, this mental shift begins as a result of media coverage as it becomes available after the main shock. Those who have experienced the earthquake throughout Southern California will begin to vigorously discuss reports heard over the media. The resulting "story" based on both media coverage and widespread discussion about the event will have a larger impact on what people think happened than the facts about what actually did happen. In the early phase of the

disaster, a wide variation in the quality and quantity of information that is made public and communicated within and across communities in Southern California serve as a basis for misinformation and rumors.

Rumors are likely to be rampant, and some will be picked up and perpetuated by the media. These include the social breakdown imagery and stereotypes common in large disasters and include: fears that the untransported dead will cause disease (despite official information to the contrary); concerns that looting will become widespread based on isolated observations of behavior that observers label as looting (that a more critical eye would determine to not be looting at all); exaggerated estimates of damage and deaths; and that insurance companies will turn their backs on the victims and not pay for losses (Fischer 1998). Over time, as the media obtain information from reliable and authoritative sources, most rumors are controlled (though not all rumors will be controlled per Houts et al. 1988; DiFonzo and Bordia 2006) and the media shift their focus from the story of the disaster to the provision of emergency-period instructions that include the location of emergency shelters, how to obtain food and water, warnings about aftershocks, and how to apply for disaster assistance.

EVACUATION DECISION MAKING

Decisions regarding evacuation will not follow immediately after the earthquake. Those whose homes have been damaged will be concerned first with their own safety and that of family members who are not present. Once united, families will assess the situation and base their decision to leave or remain in their homes on several factors—the level of damage, the type and number of utility outages, their emotional state and the actions taken, or perception of the actions taken, by neighbors. Clearly, not all post-earthquake evacuations will be discretionary, as severe damage, hazardous materials releases, potential dam failure and fire, or the likelihood of fire, will prompt evacuations ordered by authorities.

The disaster research literature points to a number of factors that guide evacuation decision making. At the outset however, it must be said that mass evacuations from an earthquake disaster, even a disaster on the regional scale considered in this scenario, to other regions and even other states, are extremely unlikely. On a basic level, some people evacuate their homes and others do not but few will abandon their homes, friends and communities to take up residence, even temporary residence, in other parts of the country. This assumption which has become conventional wisdom emerged from Hurricane Katrina in which it was indeed necessary to move large numbers of people out of New Orleans and relocate them to other areas. This disaster involved inundation of large portions of the city, loss of utilities and a virtual cessation of economic activity as well as a near total disruption of community activities. An earthquake, even one as large and damaging as a southern San Andreas event will not devastate the entire region and there will be areas that will have minimal structural damage, brief utility outages and will resume normal economic and community activities soon after the earthquake. Thus, earthquake induced evacuations will typically be local (to the homes of relatives or friends, nearby hotels or official shelters) and short-term (with the notable exception of those whose homes have been destroyed by fire).

Variables that influence evacuation decision making include situational, perceptual, emotional, and demographic factors. Situational factors include the level of structural and nonstructural damage to one's home, utility outages, and accessibility issues (e.g., level of

service disruption, road and street closures, loss of local economic activity, etc.). Perceptually, the response of people facing evacuation decisions is influenced by advisories and recommendations of officials, an assessment of personal risk, past experience with similar disasters, urging of relatives, the actions of neighbors and self-perception as a "victim" (as summarized in Mileti 1999; Goltz 2006). The emotional states of persons will also impact evacuation decisions. Goltz found in the Whittier Narrows, Loma Prieta and Northridge earthquakes that those who were most fearful during the earthquake, reported "emotional injuries" from the event, or expressed a strong desire to be in the company of others were more likely to evacuate than those for whom these factors were less salient (2006).

Several demographic variables have also been associated with evacuation behavior. Age, gender, ethnicity, household size, education, and income have all been found to influence evacuation behavior, though not consistently so. Studies have suggested that advanced age, larger household size, being male, belonging to a minority ethnicity, and having lower levels of education and income have been associated with the tendency not to evacuate, while younger persons, small households, being female, being Caucasian, and having higher income and education have been associated with the propensity to evacuate following disasters.

When people evacuate, they typically do so as family units, and evacuating families usually drive private vehicles to alternate shelter and may move from one place of temporary shelter to another. Definitions of the "family unit" for evacuees may include pets. Among pets, dogs are the most likely to be taken with the evacuating family, and pets left behind may be motivating factors for people to return home after evacuating. The homes of relatives are preferred to public shelters when they are located a reasonable distance from the disaster site. Those who populate public shelters are typically older and lower in socioeconomic status (Mileti et al. 1992). Research has also suggested that those who have evacuated make their own decisions as to when to return home, a process that does not always coincide with official recommendations and may result in inconvenience if services have not been fully restored as well as an increased probability of injury or death during cleanup (Quarantelli 1980, Dow and Cutter 2000, Siebeneck and Cova 2008).

In the scenario of a M7.8 earthquake in Southern California, evacuations will take place over the first several days following the earthquake. In the eastern portions of Los Angeles County, the cities of San Bernardino and Riverside, and the desert cities of the Coachella Valley, large numbers of people whose homes have been seriously damaged and are without electricity, water, and natural gas are likely to evacuate on the day of the earthquake and seek shelter with friends and relatives whose homes have not been damaged. Debris in the streets, nonfunctioning traffic signals, and damage to bridges will limit the mobility of many who wish to leave the immediate area, and some will either remain close to their damaged homes or relocate to public shelters, which will open during the late afternoon of the first day.

Early evacuees may set up shelters in parks or open spaces before official shelters are opened and some will remain in these locations rather than move again. Initially, shelters house only a few evacuees but as fires spread and dam-related evacuations are ordered, more and more people will arrive and more shelters will be opened during the first week after the earthquake. Shortages of food, water, and medicine cause some discontent at the

shelters, but overall, evacuees are compliant with shelter rules and are cooperative and willing to volunteer when needed. The buildings and open areas selected for shelters are varied and include neighborhood schools, churches, recreation centers, nonessential government buildings, parks, vacant lots, and fairgrounds. Where buildings are not available, tents supplied by the National Guard are erected in parks and at fairgrounds.

Millions of people would be impacted by the scenario earthquake, and a large subset of them in the eight-county region whose homes have been damaged and are without utilities will remain on the property surrounding their homes rather than seek shelter elsewhere. Many fear that their homes will be looted if they leave, have no relatives or friends nearby who might offer them refuge, and reject the idea of going to a public shelter. Although they do not require overnight accommodation at shelters, this population, which may eventually number 2.5 million, makes demands on mass-care resources as supplies of water, food, medication, and sanitary supplies are exhausted. By the third day after the earthquake, response officials establish "points of distribution" adjacent to shelters and adjust resource requests to local EOCs to assure adequate supplies for this in situ evacuation population.

Many families who have evacuated or are considering evacuation must make decisions regarding their pets and animals. Some official shelters accept pets, while others do not, and emergency operations center staff work with local animal care and control officials to identify animal shelters, veterinary hospitals, boarding kennels, pet stores, and fairground facilities to house animals that shelters are unwilling or incapable of accepting. Some evacuees resort to unofficial shelters or decide to remain on their property due to concerns about the care and safety of their pets. In response to the issues of pet care, EOCs launch public information bulletins asking evacuees to consider their pets in evacuation decisions, provide locations where pets can be housed and assign personnel to shelters to act as referral sources for animal care operations.

The percentage of victims needing public shelter is larger in this earthquake than other disasters due to several factors: Extensive urban fires have destroyed thousands of residential units to which evacuees cannot return; many victims of the earthquake are low- income people who have fewer options for alternate shelter; widespread utility outages have made it difficult to inhabit homes that may have suffered only minimal damage; and the many large aftershocks (including some that are greater than M6) have magnified fears that considerable danger remains and fuel discomfort in remaining in structures that may be further damaged or collapse. In addition, hundreds of thousands of commuters have been stranded on roads and freeways and require at least temporary shelter.

As a result of earthquake damage, widespread utility outages, fear, and discomfort due to ongoing large aftershocks, extensive fires, and a potential dam collapse, more than 255,000 households or as many as three quarters of a million people have been displaced from their homes in the eight-county area affected by the M7.8 earthquake. In some cases, those who have left their homes will return within a week; however, extensive fire damage will necessitate at least short-term shelter for approximately 542,000 people. Over a thousand public shelters will be necessary to house the large number of people who cannot find shelter elsewhere, mainly with relatives, friends, and in hotels in the region (Jones et al. 2008, Southern California Catastrophic Earthquake Response Plan, IWG6 Staff Estimate, 2010).

TAKING OTHER RESPONSE ACTIONS

Many of the tasks typically addressed by emergency response organizations immediately after the impact of a disaster go unaddressed because the demand for service delivery far exceeds the capacities of response organizations. Resulting emergency response voids do not go unaddressed since surviving victims rally to address them until outside mutual aid response organizations can converge on the area. Nine response areas where this occurs are described in the text which follows. These are: (1) fire suppression, (2) traffic control and route recovery, (3) first aid and transport of the injured, (4) sheltering, (5) food and water, (6) property protection and law enforcement, (7) dealing with the dead, (8) cleaning up debris, and (9) donations.

FIRE SUPPRESSION

In the immediate aftermath of the earthquake, overturned heat sources (lamps, candles, kitchen burners, and more), abraded and shorted electrical wiring, spilled chemicals, sheared natural gas lines, and other sources, cause hundreds of fires around the region. The density of fires is higher in mobile home parks than in neighborhoods comprised of conventional single-family homes due to the serious vulnerability to fire of manufactured homes (Lindell and Perry 1997). Initially, some fires are suppressed by residents and people at work with fire extinguishers and available water sources; however, many more fires will require trained fire fighters with appropriate equipment to be effectively extinguished. If at home, fire fighters will converge to their stations to assist their colleagues on duty. Due to telecommunications damage and saturation of the few working phone lines, many calls to fire departments will be delayed, not get through, or are never made. In some cases, residents may be able to reach close-by fire stations by foot in time to summon fire fighters, but the volume of fires, delays, and distance will mean that small fires will grow into large ones. In other cases, fire fighters will self-dispatch to an observed smoke column. Within hours, some survivors will find themselves assisting available organized fire fighters, and many survivors will monitor their surroundings for new fires for days and weeks, particularly because of aftershocks.

TRAFFIC CONTROL AND ROUTE RECOVERY

Initial post-impact travel will be to reunite family members and other intimates. People will use personal vehicles, and parents will attempt to pick up children at schools and day care centers. Most encounter obstacles and traffic jams. Some commuters on the road during impact are stranded due to debris and damage. Some survivors direct traffic in damaged areas. There are attempts to rescue stranded motorists where driving is impossible, but after trying to use their cell phones to call for help, many commuters abandon their vehicles and walk to the nearest facilities; yet others stay with their vehicles. Once operational, both Emergency Operations Centers and route recovery agencies (e.g., in California these agencies include the California Department of Transportation, the California Highway Patrol, local government public works agencies and other similar agencies) become aware of the problem posed by stranded motorists. Many motorists are rescued or have found their way to another location by the end of the first day. In the less-damaged areas, some local streets will have been cleared in the same time frame. Many survivors innovate ways to commute

in spite of obstacles including the use of bicycles and 4-wheel drive vehicles. There is very limited motorized mobility in the hardest hit areas due to the extensive damage, and local traffic is largely limited to emergency vehicles, and people desperately attempting to reunite with family members and intimates. We would speculate that commuting will increase after three days in less-damaged areas as streets and roads are cleared of debris and people travel to get supplies, sightsee, check on and visit with others, and obtain items from stores that have now opened. There is little route recovery a week after the earthquake in the hardest-hit areas.

FIRST AID AND TRANSPORT OF THE INJURED

Many people are unharmed, but many others are injured. People initially check for injuries to themselves and those in close proximity. Aid is given to the injured to the extent that it can be provided, given limited resources and expertise. Within the first half hour, those with medical training will volunteer and provide assistance to the injured on site, while others do not out of a concern for liability. First aid that can be administered onsite is completed within the first couple of hours. People with medical training and off-site staff try to report to medical centers and hospitals to volunteer for service. Many do so, but many in the hardest hit areas can not because of roadway damage. Medical staff frustration rises over the growing lack of resources. By the end of the first day, many patients have arrived at medical facilities transported by those who were with them when the earthquake struck. The injured are transported to facilities that those transporting them know about which results in an uneven distribution of patient load across facilities. Most medical staff on duty when the earthquake struck will still there after 24 hours. They have worked at capacity, have not slept, and most of them have found ways to get information to and from family members and intimates without leaving their posts. Many days later, survivors continue to give first aid in neighborhoods and continue to attempt to transport injured to hospitals despite road obstacles because of continued injuries from aftershocks and clean-up accidents.

FOOD AND WATER

Food and water are not a major immediate problem. Most people will have some stored food and water, and others will get drinkable water from their hot water heaters. But these supplies will dwindle. In three days, many will have exhausted their food supplies; and water, in many cases, will be needed even sooner. Food and water will be provided as part of shelter operations, but delivery of these resources will be hampered in severely damaged areas; these are eastern Los Angeles County, the cities of San Bernardino and Riverside, and the desert cities in the Coachella Valley. People in these areas will look to local governments for supplies. Some will go to damaged grocery and convenience stores to collect what they need to survive. Some of them will be labeled as looters by local media and authorities. Others with supply stockpiles share what they have with others. A few people will sell supplies and water at greatly inflated prices. Food and water will be more problematic in informal versus organized shelters since they will not be known to authorities. Donations will begin arriving in less-damaged areas soon after the earthquake, but they will need to be managed and distributed at the local level. Drinking water will be a very high priority and pose an acute problem because of many breaks in water pipes that will require lengthy extensive repairs and because available water will be needed to fight the many fires that are

burning throughout the region. Areas with minimal damage will provide some drinking water to heavily damaged areas; it will not be sufficient and a major effort will be mobilized to transport water by land, sea, and air.

PROPERTY PROTECTION AND LAW ENFORCEMENT

Within the first two hours after the event, some people develop concern over the lack of protection from the perceived risk of looting. This concern grows after 24 hours among many survivors in damaged areas from sporadic reports of looting in the media and hearing rumors of looting as survivors tell each other stories they have heard from other survivors. Maintaining order will become the prime concern of local law enforcement agencies. The fear of looting will be far greater than the few isolated looting cases that occur; nevertheless, looting concerns will be real to those who have them and will inhibit some from leaving their damaged property to relocate to shelters. In other cases, these concerns cause families to separate as those responsible for businesses go there to protect their inventories. After several days, people in unplanned shelters will provide their own security, and there will be scattered reports of abuse toward volunteers providing security in some of these shelters. Regular law enforcement agencies will provide security in planned shelters. After a week, the National Guard will have taken over most control and security work from local law enforcement agencies.

DEALING WITH THE DEAD

Grief-stricken families will demand proper care of dead loved ones, and the ability of mortuaries and religious organizations to operate are hampered by damage and because service demand far exceeds capacity. Within a day, attention will focus on collapsed high-rise buildings. A massive demand will rise to learn about loved ones in those buildings. Some dead are identified within the first 24 hours as search and rescue teams report to Emergency Operations Centers. Surviving family members begin to make arrangements for burials. Related activities include: picking up the body, notifying family members, funeral home arrangements, and so on. The process is slowed in hard-hit areas due to volume. After a week, families remain focused on processing their dead. Convergence of others from outside the area to commemorate the dead and grieve must be anticipated.

CLEANING UP DEBRIS

Survivors will quickly remove debris in their immediate area as soon as the ground stops shaking and, then, quickly start removing debris necessary to extract trapped victims. Several hours later and where search and rescue was not needed, the focus will shift to clearing debris from around households, worksites, and to salvage needed resources. Within a day or two, survivors who experienced lesser impacts and with inhabitable homes will have completed much of the debris removal needed to clear their houses and offer assistance to official debris removal efforts in their neighborhoods.

DONATIONS

A few hours after the earthquake, many victims will think about what they will need to survive over the next few days. By the end of the first day, local food retailers and

restaurants will have donated food, water, and services to victims and begun to work with NGOs and government response organizations to identify priorities for the distribution of supplies and water. Businesses in the affected region will continue to donate resources to survivors for many days, and volunteers approach NGOs to assist with donation management and distribution. By the end of the first week, volunteers from across the nation will approach national non-governmental organizations to volunteer their services. In the days and weeks following the earthquake, given the size of the disaster and coverage in media around the world, donations will arrive in the region, some of which will be appropriate and needed, while others will be useless and discarded (Dynes 1970, McEntire 2007).

SUMMARY AND CONCLUSIONS

We have drawn on the extensive social science literature on disasters to portray human behavior in response to a large regional earthquake scenario for Southern California. In many respects, readers may be surprised by how this behavior has been described, as it may contradict long-held assumptions about how ordinary people would react to a very extraordinary event. We have examined several actions including initial behavioral response, search and rescue, information seeking and evacuation decision making in some detail, and other actions, including fire suppression, traffic control and route recovery, first aid and transport of the injured, the provision of food and water, property protection and law enforcement, handling of the dead, debris clearance, and donations of resources in brief summary form. While all of these actions are regarded as the domain of official response agencies, we have shown that earthquake survivors share in these actions, and in many instances, perform these functions effectively prior to the arrival of organized responders.

As a foundation for our description of public response to the M7.8 earthquake disaster, we cited empirical evidence from the social science literature to establish that response of the public impacted by the disaster would be controlled, rational, constructive and consistent with pre-disaster roles in contrast to widely held assumptions that it will be impulsive, irrational, predatory or overly dependent on organizations charged with disaster response. We also noted that human behavioral response follows a certain pattern, beginning with the need to respond to the sudden onset of ground motion, which in some areas will be extremely strong, followed by the provision of assistance to others, seeking information, and making decisions regarding whether it is safe to remain in ones home or seek shelter elsewhere. In applying research findings to a large Southern California earthquake scenario, we concluded that the vast majority of Southern Californians will respond adaptively to the onset of the earthquake by taking cover and avoiding hazards, then actively assist others in the immediate area and attempt to use the media to learn more about what happened and how to obtain assistance. They will also assess their living arrangements, based on situational considerations of damage, utilities, and accessibility; perceptual factors including the recommendations of officials, the urging of others, personal risk perceptions and emotional states; and demographic characteristics (age, gender, ethnicity, household size, education and income), decide whether they will remain in their homes or seek shelter elsewhere.

In the hours and days following the earthquake, survivors will actively perform functions normally the domain of fire, police, medical professionals and other emergency responders due to inevitable delays in mobilization of an organized response and the sheer

magnitude of the disaster. In some areas such as the Coachella Valley, San Bernardino and Riverside, the response of community volunteers may be the only response in the first few days following the event. This emergent response will be most significant in search and rescue as those best positioned to respond are already in the immediate proximity of those needing rescue. As organized responders arrive and become active, informal teams of volunteers will assist them or move to other areas where they will remain active until sidelined by physical exhaustion or the arrival of response agencies. Our depiction of public response to disaster also has an important implication for efforts by government agencies and nongovernmental organizations to promote earthquake safety and community resilience. If members of the public can be relied upon to be an asset in disasters, and we have established that they are, then investment in activities like ShakeOut, first aid, CPR and CERT training, and other hazard education efforts are certainly justified.

REFERENCES

Aguirre, B. E., Wenger, D. E., and Vigo, G., 1998. A test of the emergent norm theory of collective behavior, *Sociological Forum* **13**, 301–320.

Barton, A. H., 1969. Communities in Disaster: A Sociological Analysis of Collective Stress Situations, Doubleday and Company, Inc., Garden City, NY,

Canter, D., 1980. Fires and Human Behavior, 2nd ed., Fulton Publishers Ltd., London, 272 pp.

Federal Emergency Management Agency (FEMA), 2010. Southern California Catastrophic Earthquake Response Plan, IWG6 Staff Estimate.

Difonzo, N., and Bordia, P. 2006. *Rumor Psychology: Social and Organizational Approaches*, American Psychological Association, Washington, D.C.

Dow, K., and Cutter C. L., 2000. Public orders and personal opinions: household strategies for hurricane risk assessment, *Environmental Hazards* **2**, 143–155.

Drabek, T. E., 1986. *Human Systems Responses to Disaster*: *An Inventory of Sociological Findings*, Springer-Verlag, New York, 509 pp.

Drury, J., Cocking, C., and Reicher, S., 2009. The nature of collective resilience: Survivor reactions to the 2005 London bombings, *International Journal of Mass Emergencies and Disasters* **27**, 66–95.

Dynes, R. R., 1970. *Organized Behavior in Disaster*, DC Heath, Lexington, MA, 264 pp.

Fischer, H. W., 1998. Response to Disaster: *Fact versus Fiction and Its Perpetuation*, University Press of America, Lanham, MD, 254 pp.

Goltz, J. D., Russell, L. A. and Bourque, L. B., 1992. Initial behavioral response to a rapid onset disaster: a case study of the October 1, 1987 Whittier Narrows earthquake, *International Journal of Mass Emergencies and Disasters* **10**, 43–69.

Goltz, James D., 1996. Emergency response in the great Hanshin-Awaji earthquake of January 17, 1995: planning, mobilization and interorganizational coordination, *Proceedings of the 11th World Conference on Earthquake Engineering*, Acapulco, Mexico.

Goltz, J. D., 2006. Initial Behavioral Response to a Rapid Onset Disaster: A Social Psychological Study of Three California Earthquakes, Ph.D. Thesis, University of California, Los Angeles, CA.

Houts, P. S., Cleary, P. D., and Hu, T. W., 1988. *The Three Mile Island Crisis.*, Pennsylvania State University Press, University Park, PA.

Jones, L. M., Bernknopf, R., Cox, D., Goltz, J., Hudnut, K., Mileti, D., Perry, S., Ponti, D., Porter, K., Reichle, M., Seligson, H., Shoaf, K., Treiman, J., and Wein, A., 2008. The ShakeOut Scenario: *USGS Open File Report 2008-1150 and California Geological Survey Preliminary Report 25*, http://pubs.usgs.gov/of2008/1150 and http://conservation.ca.gov/cgs, Sacramento, CA.

Kreps, G. A., 1991. Organizing for emergency management, in *Emergency Management: Principles and Practice for Local Government*, Drabek, T. S., and Hoetmer, G. J. (eds.), International City/County Management Association, Washington, D.C.: 30–54.

Lindell, M. K., and Perry, R. W., 1997. Hazardous materials releases in the Northridge earthquake: implications for seismic risk assessment, *Risk Analysis* **17**, 147–156.

McEntire, D. E., 2007. *Disaster Response and Recovery*, Wiley, Hoboken, NJ, 498 pp.

Mileti, D. S., Drabek, T. E., and Haas, J. E., 1975. *Human Systems in Extreme Environments*, Institute of Behavioral Science, University of Colorado, Boulder, CO.

Mileti, D. S., Sorensen, J. H., and O'Brien, P. W., 1992. Toward an explanation of mass care shelter use in evacuations, *International Journal of Mass Emergencies and Disasters* **10**, 25–42.

Mileti, D. S., 1999. Disasters by Design: *A Reassessment of Natural Hazards in the United States*, Joseph Henry Press, Washington, D.C. 376 pp.

Paulsen, R. L. 1981. *Human Behavior in Fire Emergencies: An Annotated Bibliography*, National Bureau of Standards, U.S.Department of Commerce, Washington, D.C.

Quarantelli, E. L. 1980. *Evacuation Behavior and Problems: Findings and Implications from the Research Literature*, Disaster Research Center, The Ohio State University, Columbus, OH.

Richter, C., 1958. *Elementary Seismology*, W.H. Freeman & Co., New York, 768 pp.

Siebeneck, L., and Cova, T., 2008. An assessment of the return-entry process for Hurricane Rita 2005, *International Journal of Mass Emergencies and Disasters* **26**, 91–111.

Tierney, K. J., Lindell, M. K., and Perry, R. W., 2001. *Facing the Unexpected: Disaster Preparedness and Response in the United States*, Joseph Henry Press, Washington, D.C., 320 pp.

Turner, R. H., Nigg, J., and Paz, D. H., 1986. *Waiting for Disaster*: *Earthquake Watch in California*, University of California Press, Berkeley, CA, 426 pp.

Turner, R. H., and Killian, L., 1987. *Collective Behavior*, Third Edition, Prentice-Hall, Inc., Upper Saddle River, NJ, 340 pp.

National Institute of Standards and Technology (NIST), 2005. Occupant behavior, egress, and emergency communications, *Federal Building and Fire Safety Investigation of the World Trade Center Disaster*, U.S. Government Printing Office, Washington, D.C., 260 pp.

(Received 12 January 2010; accepted 15 October 2010)